Isotope fractionation during impacts

Evaporation–condensation, a significant process, happens during impact events[1]. Of special interest, this process can lead to significant isotope fractionations e.g. C, O, Mg, Si, S, Fe, and Cr. The nature of the isotope fractionations is the energy for the bonds formed by the light isotope is less than bonds involving the heavy isotope[2]. In other words, during evaporation, the solid or liquid is enriched in the heavy isotopes relative to the gas[3] (Fig. 1a), whereas the solid or liquid is enriched in the light isotopes during condensation[4] (Fig. 1b). As a general rule, the earlier condensed material is enriched in lighter isotopes whereas samples with the heavier isotopes (especially positive values) could be the later condensed material or the residue of vaporization. On the basis of this, there is a great deviation from the point view which not only demonstrates that the chromium isotope is indicator of extraterrestrial materials and traces the nature of the impactor as well in terrestrial impact-related studies[5,6,7,8,9]. From the perspective of the chromium isotope values (Fig. 2), the K-T boundary samples from Stevns Klint, Denmark, and Caravaca, Spain[5] and samples from Early Archean Barberton spherule layers[6] could be the product of earlier condensation whereas Late Archean samples from Dales Gorge Layer, Carawine Dolomite and Jeerinah Formation[8] could be the later condensed material. The impact melt rocks with distinguished positive values[9] could be the

residue of vaporization.

References:

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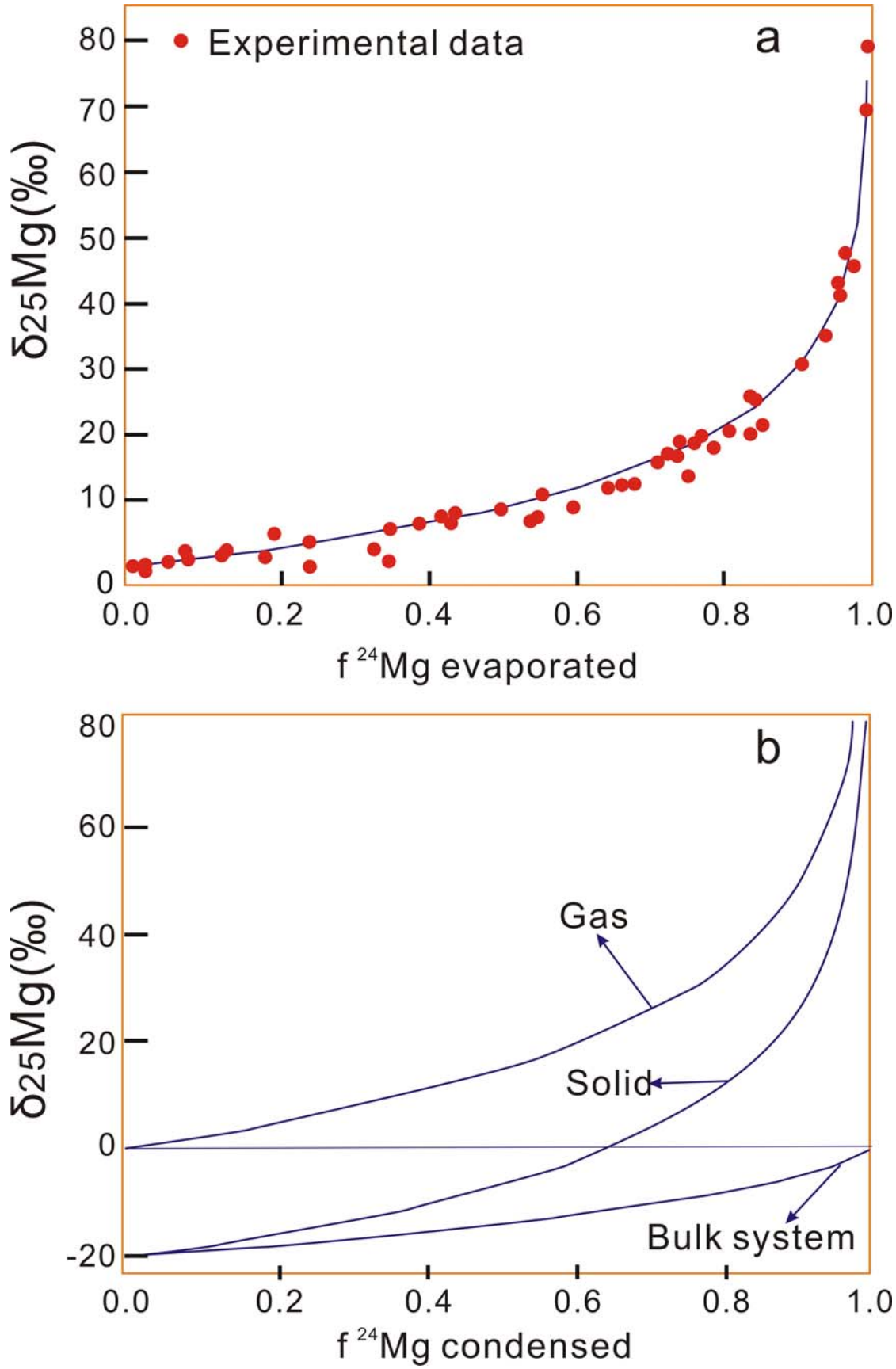
Experimental data
a
δ25Mg(‰)
80
70
60
50
40
30
20
10
0
0.0
0.2
0.4
0.6
0.8
1.0
f 24Mg evaporated
b
Gas
Solid
Bulk system
-20
f 24Mg condensed

Figurge 1a ^{24}Mg is enriched in the vapor during vaporization (modified after Richter and Dauphas et al. (2009)[3]).

Figurge 1b ^{24}Mg is enriched in the solid during condensation (modified after Richter et al. (2004)[4]).

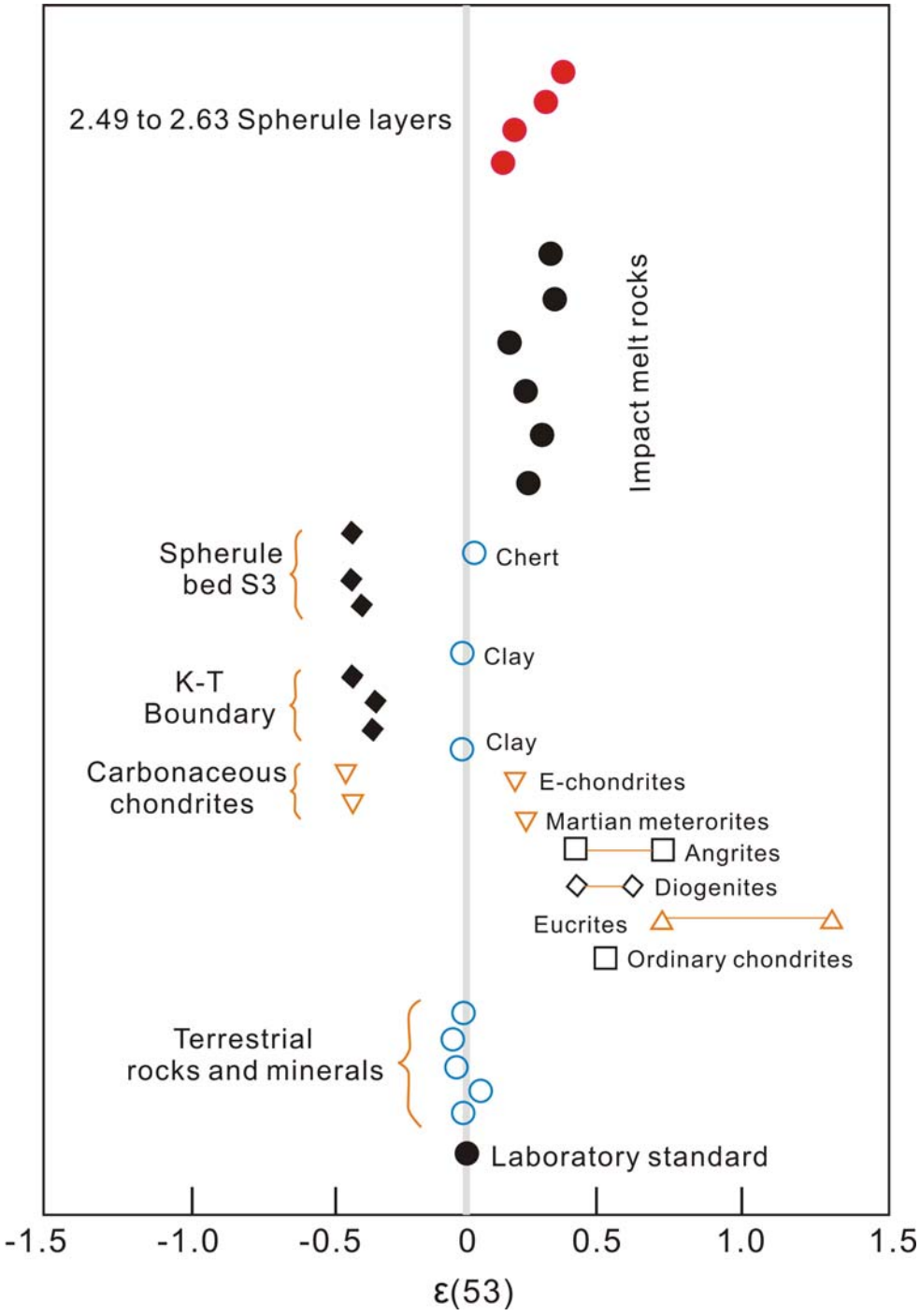
2.49 to 2.63 Spherule layers
Impact melt rocks
Spherule bed S3
Chert
Clay
K-T Boundary
Clay
Carbonaceous chondrites
E-chondrites
Martian meterorites
Angrites
Diogenites
Eucrites
Ordinary chondrites
Terrestrial rocks and minerals
Laboratory standard
-1.5
-1.0
-0.5
0
0.5
1.0
1.5
ε(53)

Fig 2 Plot of normalized ε (53Cr) of impact related samples compared with typical meteorites and normal terrestrial rocks and minerals (Modified after (Koeberl and Heinrich et al. 2007)[7] and (Simonson and McDonald et al. 2009)[8])